be recommended. The author will find it easier and more profitable to treat each type of motor separately, and then to point out the differences between the various types, than to try and establish diagrams and formulæ which will meet all cases.

VAL. A. FYNN.

SUBAQUEOUS TUNNELLING.

Tunnel Shields, and the Use of Compressed Air in Subaqueous Works. By W. C. Copperthwaite. Pp. xv+390. (London: Archibald Constable and Co., Ltd., 1906.) Price 31s. 6d. net.

THIS fine quarto volume furnishes a very valuable and comprehensive history of a system of tunnelling, especially under rivers and in water-bearing strata, which was inaugurated by Sir Marc Isambard Brunel, as regards the employment of a shield, in the celebrated Thames Tunnel between Rotherhithe and Wapping, commenced in 1825, but, owing to the inrush of the river into the works on two occasions through breaks in the stratum of clay, and financial difficulties, only completed in 1843.

The second important step in the development of the system in a practical form was, curiously enough, taken in constructing a second tunnel under the Thames rather higher up the river, crossing just above the Tower, which was commenced in February, 1869, and completed in November the same year. This Tower Subway, originally proposed by Mr. Peter Barlow, but eventually executed by the late Mr. Greathead, whose name will always be prominently associated with the system of tunnelling under consideration, was carried forward through the London Clay under the shelter of a shield, similar in principle to, though much smaller than, the Thames Tunnel shield. The shield in this instance consisted of a short wrought-iron cylinder laid horizontally, $4\frac{3}{4}$ feet long and slightly more than 7 feet internal diameter, stiffened at its front cutting-edge, and provided inside with a vertical plate diaphragm having a central opening, which could be readily closed, through which the men passed for excavating the ground in front preparatory to pushing forward the shield by a series of screws. The novelty consisted in the lining of the tunnel being formed of a series of cast-iron rings, composed of segments bolted together, which were erected under the shelter of the rear part of the cylindrical portion of the shield as it was pushed forward; and as the shield overlapped the lining of the tunnel, and left a slight annular space between the lining and the clay stratum, lime grout was injected through holes provided in the casting, so as to fill up the vacancy left by the shield in its advance. This subway traverses the London Clay throughout, at a minimum depth of 22 feet below the river-bed, no water having been encountered; and it indicates the general method of constructing tunnels by this system. The shield serves to protect the completed end of the tunnel from the fall of earth at the working face, and acts like timbering in supporting the superincumbent mass and preventing settlement above during construction, which is further insured over the completed tunnel by filling the cavities left by the advancing shield with grout.

The system, however, as successfully carried out, in the absence of water, in the Tower Subway, was not adapted for passing through water-bearing strata; and a third step, consisting in the introduction of compressed air, was essential to enable this system to cope effectually with the conditions liable to be encountered in tunnelling under rivers, or at a considerable depth below the surface, in loose ground. The completion of this system of tunnelling, by the combined use of a shield, a cast-iron lining put together under shelter of the shield, and compressed air to exclude the water from the works in traversing water-bearing strata, has enabled abandoned tunnels to be completed, and tunnels to be successfully carried out under such unfavourable conditions as would have been considered impracticable by the methods previously in use. This combination of shield, cast-iron lining, and compressed air, for carrying a tunnel through water-bearing strata, was resorted to by Mr. Greathead for the first time in 1887, in constructing the City and South London Railway, the first of the metropolitan tube railways, where it passes through the loose, water-logged gravel of the Thames basin, overlying the London Clay; and in 1889 it was adopted for continuing the Hudson Tunnel in the silt underlying the Hudson River separating New York from the mainland, when different systems of carrying forward an iron lining by the aid of compressed air, under the shelter of which a brick tunnel was constructed, proved increasingly difficult as the work advanced.

The shield for the continuation of the two single-line Hudson tunnels was $10\frac{1}{2}$ feet long and 20 feet outside diameter; whilst the cast-iron lining has an external diameter of $19\frac{1}{2}$ feet and 18 feet internal diameter, formed of rings $1\frac{1}{2}$ feet long, made up of eleven segments and a key, put in place by a revolving hydraulic erector. This work was stopped for want of funds in 1891, but was resumed in 1903 and completed last year. Where the silt traversed was very soft, the shield was kept closed and pushed forward by sixteen hydraulic rams; and to avoid unequal settlement of the tube under the weight of a train, it has been supported at intervals on iron piles driven down to a hard stratum underlying the silt. Compressed air had been used successfully for many years in constructing foundations and piers of bridges under water, or in water-bearing strata, before it was applied to subaqueous tunnelling; but whereas in bottomless, vertical caissons, the compressed air forces out the water uniformly all over the bottom, the pressure of the air at the open end of a horizontal tube meets with less opposition from the water at the top than at the bottom, where the head of water is greater, in proportion to the diameter of the tube. Accordingly, in large tubes there is a liability in traversing loose soil for the air to escape through the stratum at the top, and for the water to rush in simultaneously at the bottom. To provide for the safety of the men in such a contingency, in addition to two or three platforms at the back of the diaphragm of the shield, with openings at each stage which can

be readily closed, a metal screen is hung down the upper half of the tube at the back to provide an air space at the top, to which the men can escape by an air-lock through the screen on the occurrence of an inrush of water, and pass out through an emergency air-lock in the bulkhead behind.

The author has collected together a large quantity of information from a variety of publications, so as to present a fairly complete record of the numerous subaqueous tunnels carried out by means of a shield, and more particularly those where compressed air has been also resorted to, of which there are several interesting examples in Great Britain, France, and the United States, all constructed within the last twenty years. The clear descriptions are very well illustrated by numerous drawings; and the book deserves a cordial welcome from all persons who are concerned or interested in the latest developments of subaqueous tunnelling.

PROBLEMS IN METABOLISM.

Problems in Animal Metabolism. By J. B. Leathes. Pp. viii+205. (London: John Murray, 1906.) Price 7*s.* 6*d.* net.

THIS volume is the latest of the series that Mr. Murray is issuing in connection with the work of the physiological laboratory of the London University. The subject Dr. Leathes took for his lectures is perhaps the most important one in the whole of chemical physiology. In a study of metabolism one seeks to understand the innermost workings of the living cells, and thus to comprehend the sum total of the chemistry of life. In order, however, to pave the way for such complete knowledge it is necessary to study individual chemical reactions, the items that go to form the final sum; and so in the interesting book Dr. Leathes has produced he is mainly concerned with a separate consideration of the way in which the carbohydrates, fats, and proteids are utilised, and finally catabolised.

The author has taken infinite pains to get his facts correct, and has presented the subject in an extremely clear way. He is able to point out quite lucidly how far present knowledge carries us, and where speculation steps in to fill up the gaps. One becomes conscious of the width of these gaps when one realises that any exact knowledge of how simple substances like sugar are ultimately converted into water and carbon dioxide in the body is at present lacking. In the case of the more complex materials, such as the proteids, hypotheses are still more numerous, because our facts are still scantier.

The whole work is full of pregnant suggestions, and the writing is so attractive that one can confidently recommend it to all those who desire a picture of exactly where physiology stands at the present day in relation to these important matters.

The spirit of the physiological chemist should not be to make this branch of science an offshoot of chemistry, but to use organic chemistry as the means to an end. This is the correct attitude that Dr. Leathes assumes throughout. In the remote past so-called physiology was largely anatomy. When all that anatomy could contribute had been learnt, it was found that the real work of the physiologist was only beginning. So, too, as Dr. Leathes points out, we look forward to a future in which chemistry will have contributed its share, and the workers will discover that physiology has still problems before it which cannot be learnt from pure chemistry, any more than the whole of physiology can be learnt by dissections.

The subject of proteid metabolism is in the air just now, so it is specially interesting to ascertain what views Dr. Leathes holds in relation to it. He accepts the view which is daily gaining greater credence, that in digestion the albuminous molecule is broken up into quite simple substances, mainly of the amino-acid variety. He believes that these are absorbed as such, and that the work of proteid synthesis is carried out by the living cells of the tissues from these crystallisable products transported to them by the blood and lymph. He admits this hypothesis is in the unproven condition, but has himself been successful in showing that the nitrogen of the blood, combined in amino-acids and molecules of that order, is increased during absorption. To identify the individual amino-acids is a matter of much greater difficulty, and a simple calculation shows how greatly even the most abundant of them must be diluted by the whole mass of the blood even during the progress of the absorption of a considerable meal.

His views on the catabolism that proteids undergo very largely coincide with those of Folin. The nitrogen of ingested albumin is readily split off with comparatively little loss of energy and discharged *viâ* the liver as urea. The non-nitrogenous residue is therefore available as a source of heat and energy in much the same way as fat and carbohydrates are. Until, therefore, we know how the cells dispose of such simple organic compounds as fat, our knowledge regarding the fate of the fat-like moiety of proteids must be in abeyance. Dr. Leathes puts this much more fully, but very clearly, which makes one wonder why, in another part of the book, all his arguments are against the possible origin of fat from proteid intra-cellularly.

Is it, then, advisable to limit our proteid intake to the low level advocated so forcibly by Chittenden? Should we take only sufficient to balance the small amount of proteid waste that is associated with tissue activity? In his answer to this question Dr. Leathes has taken an independent and original line. He admits that the necessary minimum is much less than the conventional dietary of 100 grams daily, but he thinks it does not necessarily follow that it is unphysiological to take more than the minimum, any more than it is unphysiological to take any food which yields more than the minimum of fæcal refuse. In the infant, the dietary provided by nature in the amount of milk it takes is, even after making due allowance for growth, at least ten times greater than the minimum. The minimum can therefore hardly be normal for the adult; and a possible reason for this is that there may be a few members of the amino-